Compact, Efficient Deformable Mirrors for Space-Borne Telescopes

Chad H. Joshi, Emanuel S. Bobrov
Energen, Inc.
7 Riverside Avenue
Bedford, Massachusetts 01730-1528
(617)271-9876

This work supported in part by
National Aeronautics and Space Administration
through the
Small Business Innovation Research (SBIR) Program

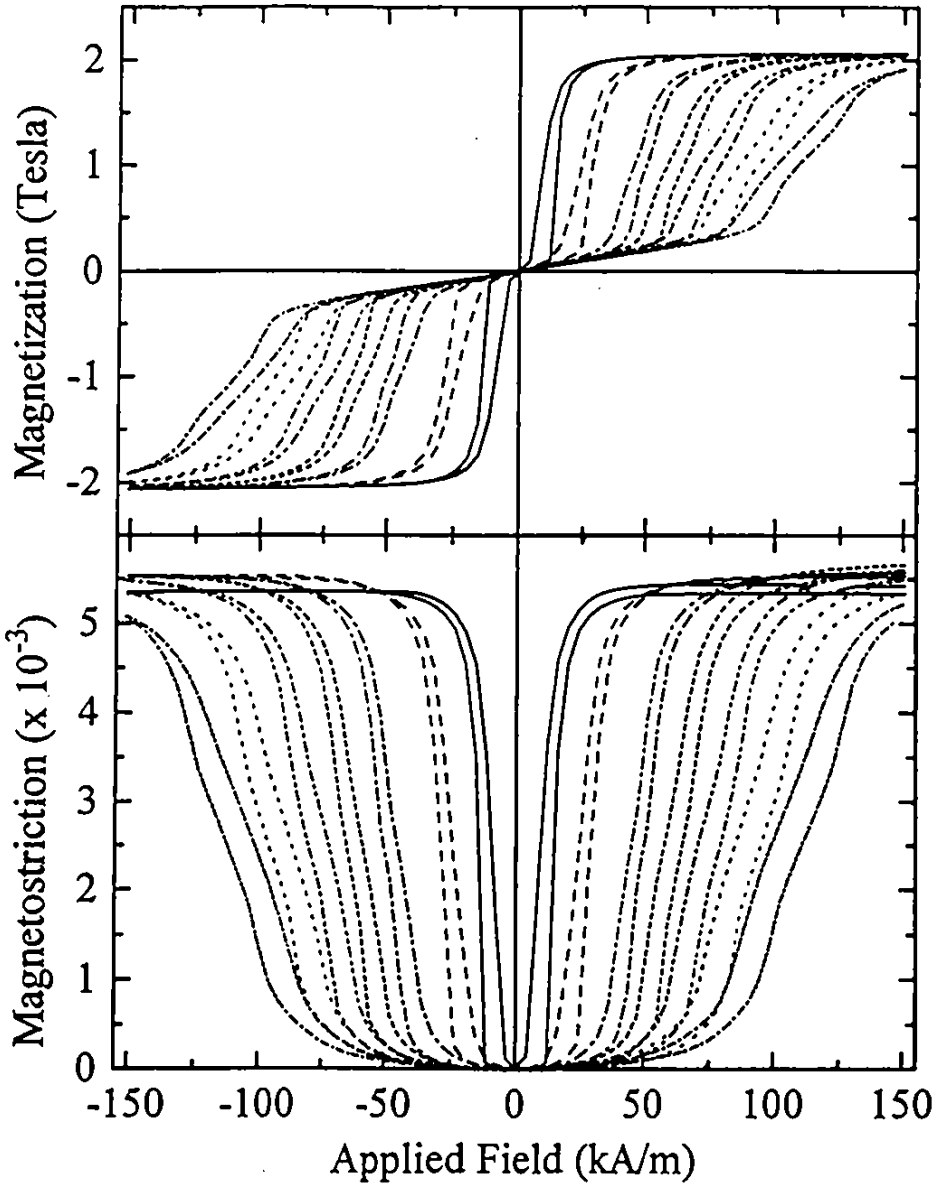
Abstract:

Energen, Inc. is developing actuators for cryogenic deformable mirrors based on magnetostrictive materials. Magnetostrictive actuators have advantages over piezoelectric actuators because of low voltage operation and negligible power dissipation. The magnetostrictive materials come from the family of alloys consisting of $Tb_{1-x}Dy_xZn$ which exhibit saturation magnetostrictions of over 0.5% with little hysteresis resulting in a compact and lightweight actuator. When excited with high current density superconducting coils, the actuators provide very precise postioning capability with negligible power dissipation. Energen's innovative design for the deformable mirror assembly make efficient use of the magnetostrictive material and superconducting coils to reduce system weight and allows actuators to be placed more closely than existing deformable mirror systems enabling higher spatial frequency resolution and compensation for larger thermal distortions in the primary mirror.

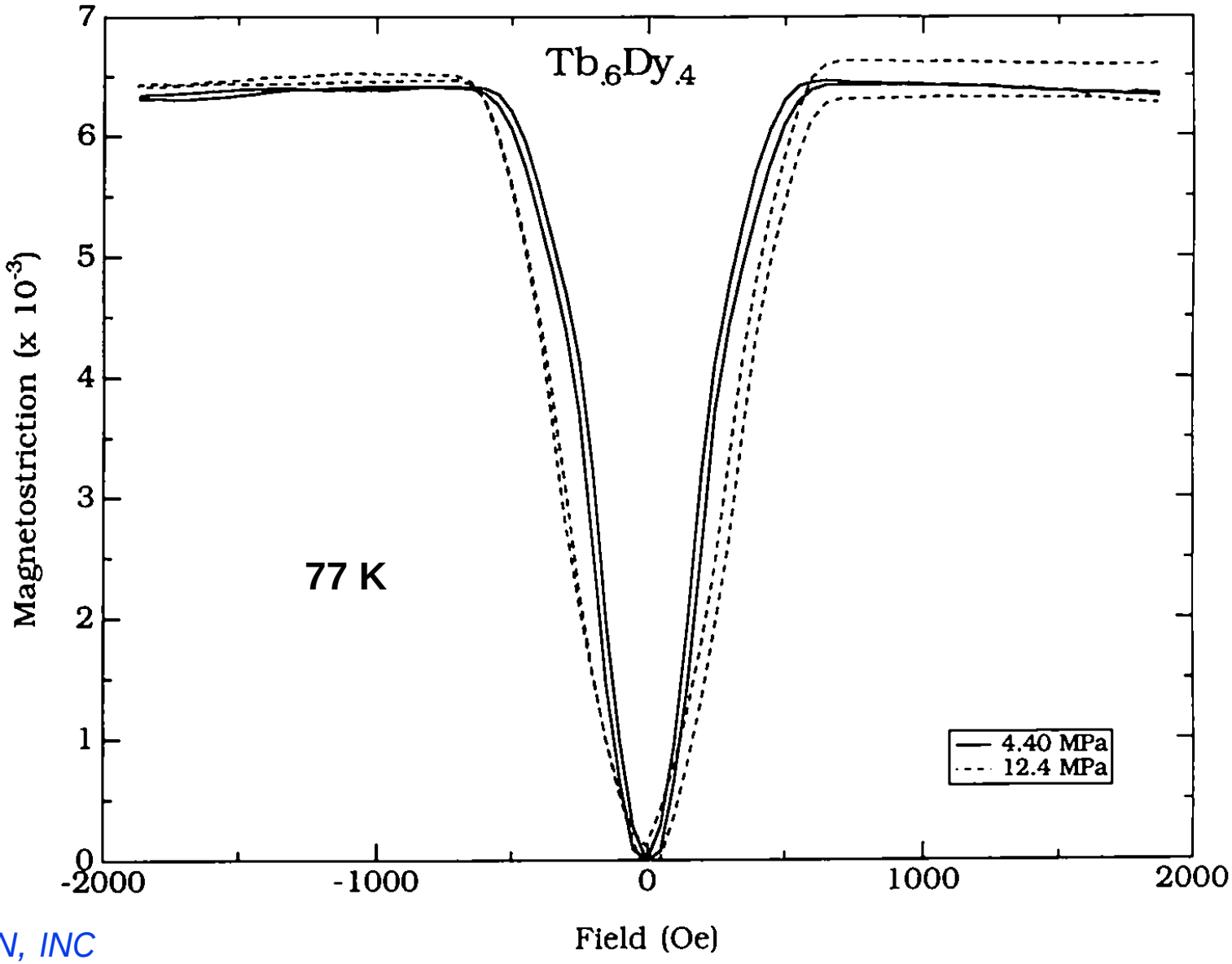
Some Magnetostrictive Materials

Material	Saturation Strain (ppm)	Curie Temperature (K)
Ni	-50	633
Fe	-14	1043
$SmFe_2$	-2340	688
Fe_3O_4	60	858
$DyFe_2$	650	635
$TbFe_2$	2630	703
$Tb_{0.3}Dy_{0.7}Fe_{1.9}$ (Terfenol-D)	1600-2400	653
$Tb_{0.6}Dy_{0.4}$ @ 77 K	6300	215
TbZn	4500-5500	180
TbDyZn	5000	250

Magnetostriction of TbZn



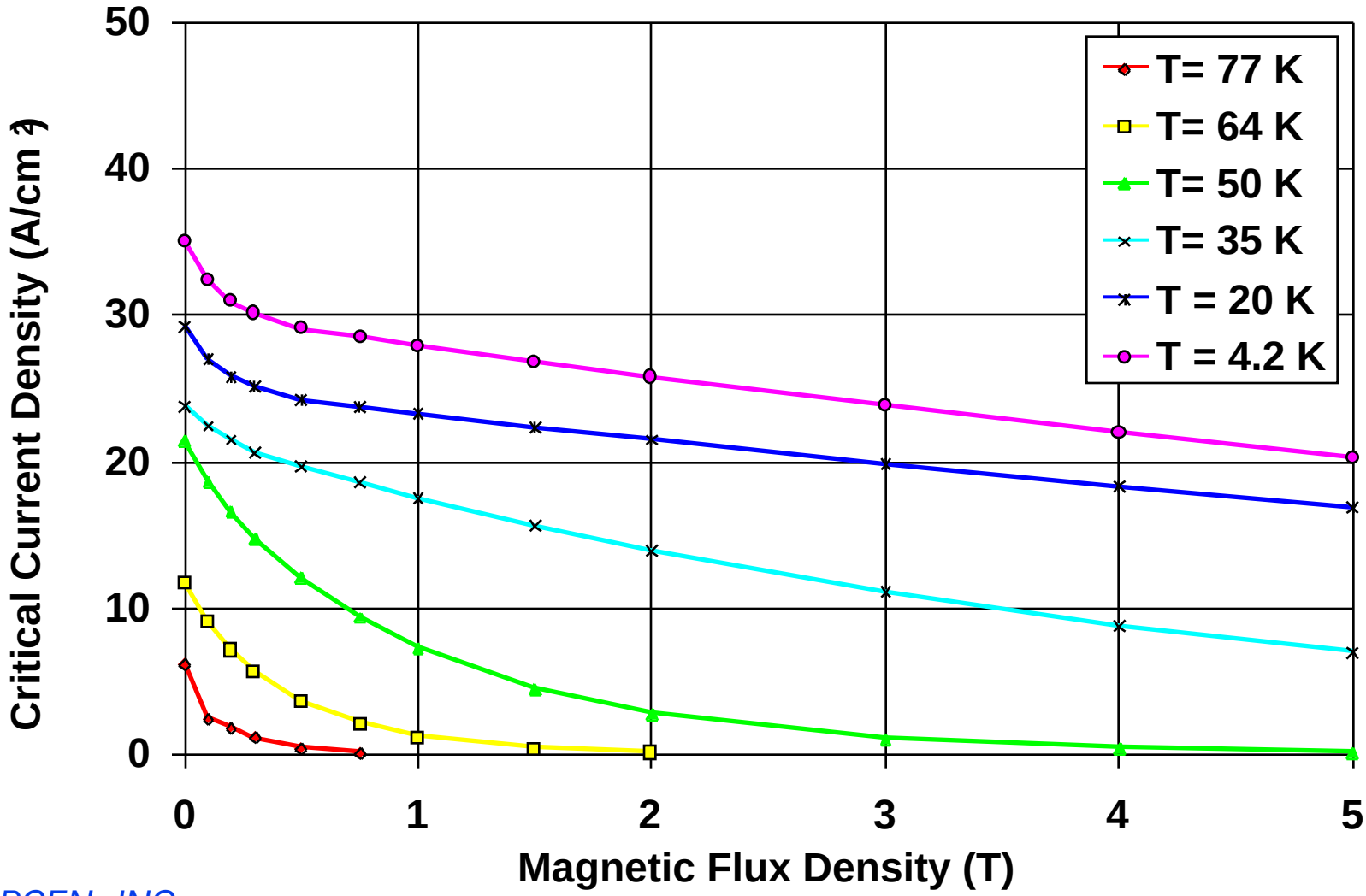
Magnetostriction of TbDy



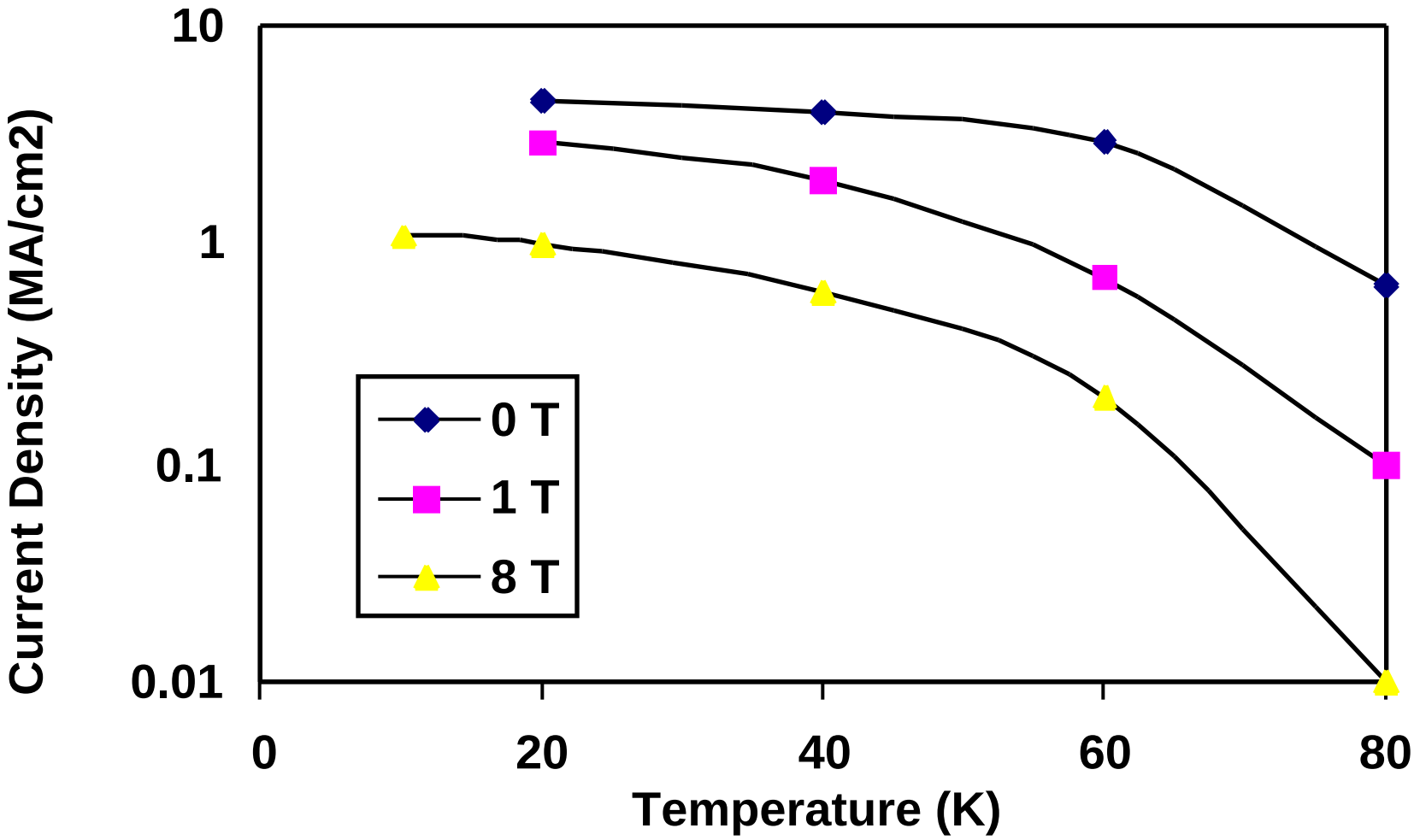
High Temperature Superconductors

Material	Critical Temperature (K)
$YBa_2Cu_3O_x$	92
$Bi_2Sr_2CaCu_2O_x$	84
$(PbBi)_2Sr_2Ca_2Cu_3O_x$	105
$Tl_2Ba_2CaCu_2O_x$	125

Critical Current in PbBSCCO

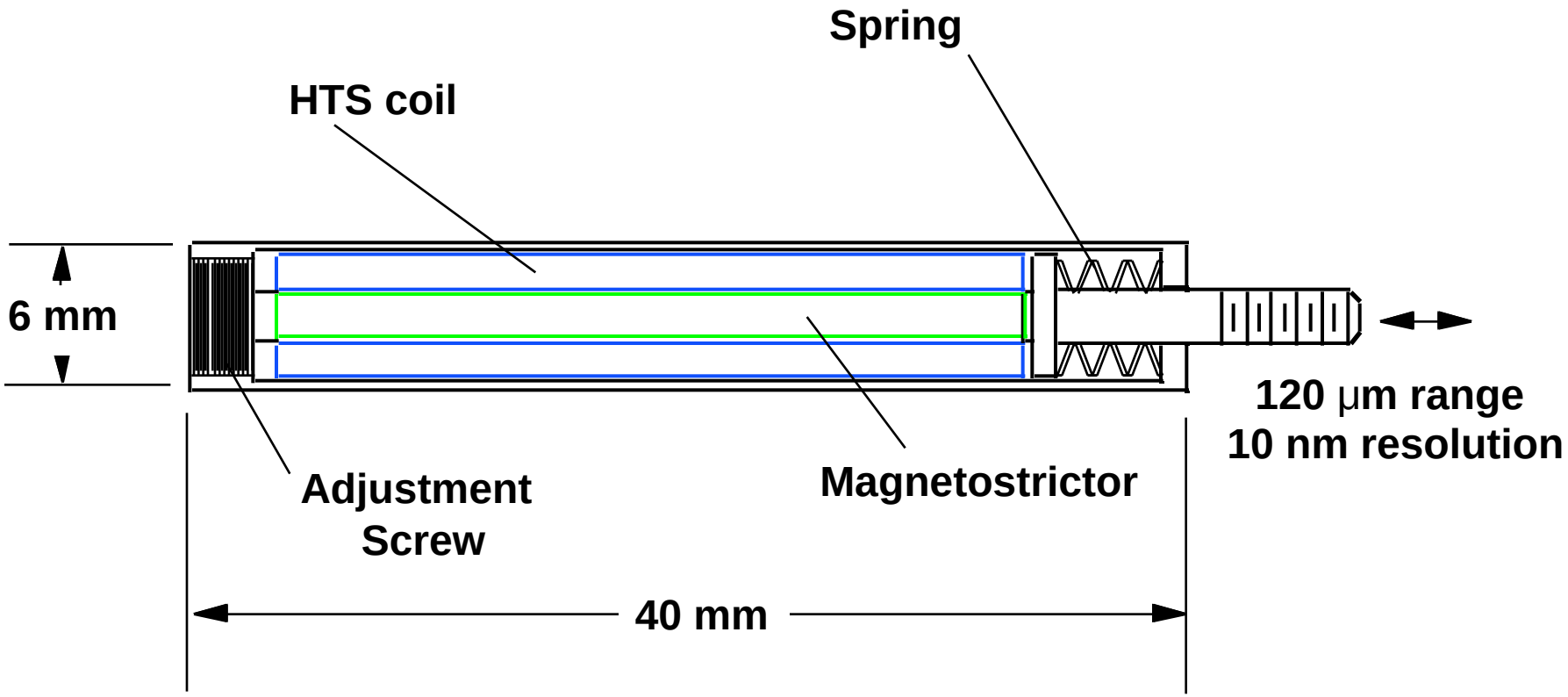


Coated YBCO Conductor

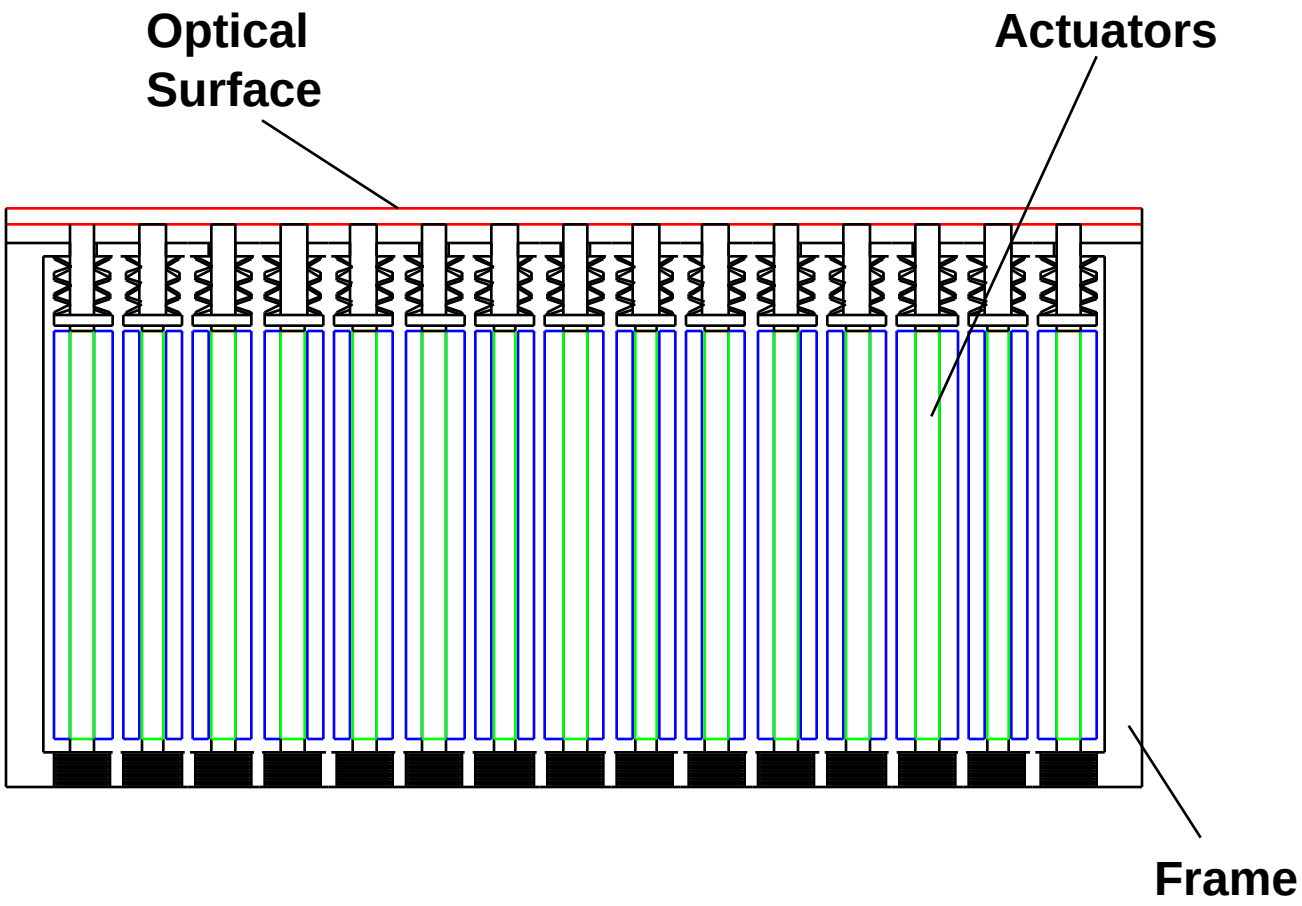


ENERGEN, INC

Magnetostrictive Actuator



Mirror Conceptual Design



Magnetostrictive actuators provide...

- high spatial frequency resolution
- greater wavefront error correction
- low voltage operation
- high pulling and pushing forces
- negligible power dissipation